(19) Europäisches Patentamt
European Patent Office
Office européen des brevets

(11) Publication number: 0 335 493 B1

(12) **EUROPEAN PATENT SPECIFICATION**

(45) Date of publication of patent specification: 29.11.95 Bulletin 95/48

(51) Int. Cl.[6]: H03B 5/32

(21) Application number: 89301631.1

(22) Date of filing: 20.02.89

(54) Oscillator.

(30) Priority: 27.02.88 JP 45666/88

(43) Date of publication of application: 04.10.89 Bulletin 89/40

(45) Publication of the grant of the patent: 29.11.95 Bulletin 95/48

(84) Designated Contracting States: DE FR GB

(56) References cited:
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EP 0 335 493 B1

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Description

The present invention relates to an oscillator using a piezo-electric device.

A conventional television equipment and communication equipment often employ an oscillator using a piezo-electric device such as a surface acoustic wave (SAW) resonator or crystal resonator in a portion requiring a low-noise, high-stable frequency source.

The suitability of SAW resonators for high frequency use is described in "Design of Crystal and other Harmonic Oscillators", Benjamin Parzen, John Wiley & Sons 1983, Chapter 3.4, pp 100-102.

Fig. 3 exemplifies a typical Colpitts oscillator using an SAW resonator.

In Fig. 3, reference numeral 51 denotes an oscillating transistor. The base of the transistor 51 is connected to the positive terminal of a DC power source 1 through a resistor 52 and to the negative terminal thereof through a resistor 53. The collector of the transistor 51 is connected to the positive terminal of the power source 1 through a resister 54, and the emitter is connected to the negative terminal of the power source 1 through a resistor 55. Thus, a DC bias voltage current is supplied to the transistor 51.

A capacitor 58 for bypassing a high-frequency current is connected in parallel with the resistor 55. A capacitor 56 is connected between the base of the transistor 51 and the negative terminal of the power source 1. A capacitor 57 is connected between the collector of the transistor 51 and the negative terminal of the power source 1. These capacitors 56 and 57 match an impedance of an SAW resonator 49 connected in parallel with the base-collector path of the transistor 51 through a capacitor 59 with an impedance of this oscillator, thus causing oscillation.

If the gain of the transistor 51 is sufficiently large, with the above circuit arrangement, the oscillator is oscillated at a resonant frequency of the SAW resonator 49, and a signal having the above-mentioned frequency is output from an output terminal 61 connected to the collector of the transistor 51.

Note that in Fig. 3 , the capacitor 59 connected in series with the SAW 49 and the resistor 60 connected in parallel therewith are used not to apply a DC voltage to the SAW resonator 49. More specifically, a finger electrode pitch of interdigital transducers 50 of the SAW resonator 49 is as small as several µm. When an aqueous component of steam or dust becomes attached to the transduers, if a DC voltage is applied across the transducers, the transducers may be electrically corroded or may be destroyed due to discharging.

In a television or communication equipment, in order to reduce the size, weight, and cost, the degree of integration of the circuit is increasing. Thus, an oscillator to be used preferably has a higher degree of integration. However, it is difficult to integrate a piezo-electric resonator such as an SAW resonator on a single substrate together with other circuits. Therefore, integration of an oscillator circuit portion excluding the piezo-electric device has been studied.

However, the circuit shown in Fig. 3 requires four capacitors, and is not suitable for an integrated circuit. This is because in the integrated circuit, a capacitor has a larger shape than those of transistors or resistors.

In particular, in Fig. 3, the capacitance of the capacitor 59 must be sufficiently larger than a transducer capacitance of the SAW resonator 49, i.e., several tens of pF to several hundreds of pF. In addition, the absolute value of the impedance of the capacitor 58 must be sufficiently smaller than the resistance of the resistor 55 at an oscillation frequency. For this purpose, the capacitance of the capacitor 58 must also be several tens of pF to several hundreds of pF. In order to realize such a capacitance on an integrated circuit, an area of 10,000 μm^2 to 1 mm^2 is necessary. It is uneconomical to use such an area for one capacitor in an integrated circuit.

In the circuit shown in Fig. 3, a high-frequency current flowing through the collector of the transistor 51 flows through the power source 1 through the resistor 54 and the capacitor 58. If another circuit is connected to the power source 1, the high-frequency current serves as a noise source for the other circuit. In contrast to this, when a noise component from the other circuit enters the line of the power source 1, since the circuit shown in Fig. 3 is of unbalanced type, the noise component enters the circuit through the resistor 52 or 54 or other elements, and as a result, the oscillation frequency is modulated or the noise component appears in the output signal. These influences are conspicuous when the oscillator shown in Fig. 3 and other circuits are mounted on a single integrated circuit substrate.

In this manner, it is very difficult to integrate the conventional oscillator shown in Fig. 3.

It is an object of the present invention to provide an oscillator in which a DC voltage is not applied to a piezo-electric device.

It is another object of the present invention to provide an oscillator which does not serve as a noise source for other circuits, and is not easily influenced by the other circuits.

It is still another object of the present invention to provide an oscillator suitable for an integrated circuit.

The present invention is defined by claim 1. In an oscillator so defined, the collectors of a pair of transistors are connected to one terminal of a DC power source through resistors, the emitters are connected to the other terminal of the DC power source through a common current-source, and the bases are connected to a bias circuit for applying a bias voltage, thus constituting a differential amplifier circuit. At

least one port of a piezo-electric device having at least two ports on a single substrate is connected between the collectors of the transistors, and the remaining port is connected between the bases.

With the above arrangement, in this oscillator, a positive feedback is performed through the piezo-electric device from the output of the differential amplifier circuit, i.e., between the collectors of the pair of transistors to the input of the differential amplifier circuit, i.e., between the bases of the pair of transistors at a resonant frequency of the piezo-electric device, thus oscillating the oscillator. As a result, the oscillation output is obtained from the output of the differential amplifier circuit.

In this oscillator, the resistances of the resistors connected to the collectors of the pair of transistors are equal to each other, and the entire circuit serves as a completely balanced arrangement. The pair of transistors perform symmetrical operations in a DC manner, and the DC potentials of the collectors, bases, and emitters are equal to each other in both the transistors. Thus, no DC voltage is applied across the transducers at the port of the piezo-electric device connected between the collectors, and no DC voltage is applied across the transducers at the remaining port connected between the bases. The pair of transistors serve as the differential amplifier circuit. When a current in one transistor is increased, a current in the other transistor is decreased. Thus, the current in the entire circuit is always constant, and no high-frequency current flows through the DC power source upon oscillation.

A crystal oscillator utilizing a non-SAW resonator with outputs having 180° phase difference is described in SU-A-949 770.

Furthermore, in these oscillators, the common current-source connected to the emitters may be a resistor means.

As described above, according to the oscillator of the present invention, since no DC voltage is applied across the transducers at the ports of the piezo-electric device having at least two ports, degradation of this piezo-electric device can be prevented. The circuit has a completely symmetrical arrangement, and only a DC current flows from the power source. For this reason, the oscillator does not serve as a noise source for other circuits connected to the power source, and is not easily influenced by noise from the other circuits. In addition, since the oscillator does not require a large-capacitance capacitor, it is very suitable for an integrated circuit.

Fig. 1 is a circuit diagram of a first embodiment of the present invention;

Fig. 2 is a circuit diagram of a second embodiment of the present invention; and

Fig. 3 is a circuit diagram of a conventional circuit.

Two embodiments of the present invention will now be described with reference to the accompanying drawings.

Fig. 1 is a circuit diagram of a first embodiment.

In this embodiment, not only no DC voltage is applied across neither the transducers at one port 3 of a 2-port SAW resonator 2 nor the transducers at the other port 4, but also no DC voltage is applied across the ports 3 and 4.

In Fig. 1, the base of a transistor 27, the collector of which is connected to one terminal of a DC power source 1, is connected to the collector of a transistor 5. The emitter of the transistor 27 is connected to the other terminal of the DC power source 1 through a diode 29 and a resistor 31. Similarly, the base of a transistor 28, the collector of which is connected to one terminal of the DC power source 1, is connected to the collector of a transistor 6. The emitter of the transistor 28 is connected to the other terminal of the DC power source 1 through a diode 30 and a resistor 32. The port 3 of the 2-port SAW resonator 2 is connected not between the collectors of the transistors 5 and 6 but between the connecting node between the diode 29 and the resistor 31 and the connecting node between the diode 30 and the resistor 32.

In this circuit, the DC bias voltage value of the collector-base path of each of the transistors 5 and 6, which is determined by a voltage applied from a bias circuit 10 to the bases of the transistors 5 and 6, the resistances of resistors 8 and 9, and the current value of a DC current-source 7, is designed to be equal to a sum voltage value of the base-emitter voltage of each of the transistors 27 and 28 and the voltage across the two terminals of each of the diodes 29 and 30. More specifically, the DC potential of the port 3 of the 2-port SAW resonator 2 is equal to the Dc potential of the port 4.

According to this embodiment, not only no DC voltage is applied across neither the transducers at the port 3 of the 2-port SAW resonator 2 nor the transducers at the port 4, but also no DC voltage is applied across the ports 3 and 4. Note that in Fig. 1, output terminals 13 and 14 are connected to the collectors of the transistors 5 and 6 but may be connected to the emitters of the transistors 27 and 28 or to the two terminals of the port 3.

Fig. 2 is a circuit diagram of a second embodiment having the same object as in the embodiment shown in Fig. 1.

In this embodiment, the diodes 29 and 30 shown in Fig. 1 are replaced with resistors 33 and 34, respectively, and the resistors 31 and 32 are replaced with DC current-sources 35 and 36, respectively.

In the circuit shown in Fig. 2 the collector-base DC bias voltage value of each of transistors 5 and 6 is designed to be equal to a sum voltage value of the base-emitter voltage of each of the transistors 27 and 28 and a voltage across two terminals of each of the resistors 33 and 34. Note that the voltage across the two terminals of each of the resistors 33 and 34 is de-

termined by the resistances of the resistors 33 and 34 and the current values of the DC current-sources 35 and 36.

According to the above-mentioned arrangement and design, the DC potential of the port 3 of the 2-port SAW resonator 2 is equal to the DC potential of the port 4.

According to this embodiment, not only no DC voltage is applied across neither the transducers at one port 3 of a 2-port SAW resonator 2 nor the transducers at the other port 4, but also no DC voltage is applied across the ports 3 and 4.

Note that in Fig. 2, output terminals 13 and 14 are connected to the collectors of the transistors 5 and 6 but may be connected to the emitters of the transistors 27 and 28 or to the two terminals of the port 3.

The diodes 29 and 30 shown in Fig. 1 and the resistors 33 and 34 shown in Fig. 6 can be omitted. In this case, the collector-base bias voltage of each of the transistors 5 and 6 is set to be equal to the base-emitter voltage of each of the transistors 27 and 28, i.e., about 0.7 V.

In the above-mentioned embodiments, the oscillation frequency can be finely adjusted.

For example, a capacitor can be connected between the collectors or bases of the transistors 5 and 6, or between the collector of the transistor 5 and one terminal of the DC power source 1 and between the collector of the transistor 6 and one terminal of the DC power source 1, or between the base of the transistor 5 and one terminal of the DC power source 1 and between the base of the transistor 6 and one terminal of the DC power source 1, so that the oscillation frequency is finely adjusted on the basis of the capacitance of the capacitor. This also applies to other embodiments.

In the above embodiments, the output terminals are connected to the outputs of the differential amplifier circuit, but may be connected to the inputs of the differential amplifier circuit. More specifically, the outputs can be obtained from two terminals of any port of the piezo-electric device.

The specific embodiments of the present invention has been described. However, various other changes and modifications of the present invention mav be made within the scope of the invention as defined by the appended claims. The above embodiments may be combined.

Claims

1. An oscillator wherein a differential amplifier circuit is constituted by connecting collectors of first and second transistors (5,6) to one terminal of a DC power source (1) through first and second resistors (8,9), these connection points constituting output terminals of the oscillator, connecting emitters of said first and second transistors (5,6) to the other terminal of said DC power source (1) through a first current source (7), and connecting bases of said first and second transistors (5, 6) to a bias circuit (10) for applying a bias voltage; one port (4) of a surface acoustic wave resonator (2) with a resonant frequency of several hundreds of MHz having at least two ports (3,4) on a first substrate is connected between said bases of said first and second transistors (5,6), wherein the connection polarities of at least two ports (3,4) or the acoustic distance between them is such that the voltage at these ports are in phase with each other, a collector of a third transistor (27) is connected to the one terminal of said DC power source (1), an emitter of said third transistor (27) is connected to the other terminal of said DC power source (1) through a third resistor (31) or second current source (35), a base of said third transistor (27) is connected to said collector of said first transistor (5), a collector of a fourth transistor (28) is connected to the one terminal of said DC power source (1), an emitter of said fourth transistor (28) is connected to the other terminal of said DC power source (1) through a fourth resistor (32) or a third current source (36), a base of said fourth transistor (28) is connected to said collector of said second transistor (6), and at least one of the remaining ports (3) of said surface acoustic wave resonator (2) is connected between a first connecting node between said emitter of said third transistor (27) and said third resistor (31) or said second current source (35) and a second connecting node between said emitter of said fourth transistor (28) and said fourth resistor (32)or said third current source (36), whereby a DC voltage is neither applied at the ports (3,4) of the resonator (2) nor across said ports (3,4) of the resonator (2).

2. An oscillator according to claim 1, wherein said differential amplifier circuit further comprises a first diode (29) connected between said first connecting node and said emitter of said third transistor (27); and a second diode (30) connected between said second connecting node and said emitter of said fourth transistor (28).

3. An oscillator according to claim 1, wherein said differential amplifier circuit further comprises a third resistor (33) connected between said first connecting node and said emitter of said third transistor (27), and a fourth resistor (34) connected between said second connecting node and said emitter of said fourth transistor (28).

4. An oscillator according to any one of claims 1 to 3, wherein all the circuits except said surface

acoustic wave resonator are integrated on a second substrate.

5. An oscillator according to any one of claims 1 to 3, wherein said first, second, third and fourth transistors are composed of field effect transistors.

Patentansprüche

1. Oszillator, bei dem eine Differenzverstärkerschaltung so aufgebaut ist, daß Kollektoren eines ersten und eines zweiten Transistors (5, 6) über einen ersten und einen zweiten Widerstand (8, 9) mit einem Anschluß einer Gleichstromquelle (1) verbunden sind, wobei diese Verbindungspunkte Ausgangsanschlüsse des Oszillators bilden, Emitter des ersten und des zweiten Transistors (5, 6) über eine erste Stromquelle (7) mit dem anderen Anschluß der Gleichstromquelle (1) verbunden sind und Basen des ersten und zweiten Transistors (5, 6) mit einer Vorspannungsschaltung (10) zum Anlegen einer Vorspannung verbunden sind; eine Öffnung (4) eines akustischen Oberflächenwellenresonators (2) mit einer Resonanzfrequenz von mehreren hundert Megahertz und mindestens zwei Öffnungen (3, 4) auf einem ersten Substrat zwischen die Basen des ersten und des zweiten Transistors (5, 6) geschaltet ist, wobei die Verbindungspolaritäten von mindestens zwei Öffnungen (3, 4) oder die akustische Distanz zwischen ihnen derart ist, daß die Spannung an diesen Öffnungen miteinander phasengleich ist, ein Kollektor eines dritten Transistors (27) mit dem einen Anschluß der Gleichstromquelle (1) verbunden ist, ein Emitter des dritten Transistors (27) über einen dritten Widerstand (31) oder eine zweite Stromquelle (35) mit dem anderen Anschluß der Gleichstromquelle (1) verbunden ist, eine Basis des dritten Transistors (27) mit dem Kollektor des ersten Transistors (5) verbunden ist, ein Kollektor eines vierten Transistors (28) mit dem einen Anschluß der Gleichstromquelle (1) verbunden ist, ein Emitter des vierten Transistors (28) über einen vierten Widerstand (32) oder eine dritte Stromquelle (36) mit dem anderen Anschluß der Gleichstromquelle (1) verbunden ist, eine Basis des vierten Transistors (28) mit dem Kollektor des zweiten Transistors (6) verbunden ist und mindestens eine der verbleibenden Öffnungen (3) des akustischen Oberflächenwellenresonators (2) zwischen einen ersten Verbindungsknoten zwischen dem Emitter des dritten Transistors (27) und dem dritten Widerstand (31) oder der zweiten Stromquelle (35) und einen zweiten Verbindungsknoten zwischen dem Emitter des vierten Transistors (28) und dem vierten Widerstand (32) oder der dritten Stromquelle (36) geschaltet ist, wodurch eine Gleichspannung weder an die Öffnungen (3, 4) des Resonators (2) noch über die Öffnungen (3, 4) des Resonators (2) angelegt wird.

2. Oszillator nach Anspruch 1, wobei die Differenzverstärkerschaltung ferner aufweist: eine erste Diode (29), die zwischen den ersten Verbindungsknoten und den Emitter des dritten Transistors (27) geschaltet ist; und eine zweite Diode (30), die zwischen den zweiten Verbindungsknoten und den Emitter des vierten Transistors (28) geschaltet ist.

3. Oszillator nach Anspruch 1, wobei die Differenzverstärkerschaltung ferner aufweist: einen dritten Widerstand (33), der zwischen den ersten Verbindungsknoten und den Emitter des dritten Widerstands (27) geschaltet ist und einen vierten Widerstand (34), der zwischen den zweiten Verbindungsknoten und den Emitter des vierten Transistors (28) geschaltet ist.

4. Oszillator nach einem der Ansprüche 1 bis 3, wobei alle Schaltungen mit Ausnahme des akustischen Oberflächenwellenresonators auf einem zweiten Substrat integriert sind.

5. Oszillator nach einem der Ansprüche 1 bis 3, wobei die ersten, zweiten, dritten und vierten Transistoren aus Feldeffekttransistoren bestehen.

Revendications

1. Oscillateur dans lequel un circuit d'amplificateur différentiel est constitué en connectant des collecteurs de premier et second transistors (5, 6) à une borne d'une source d'alimentation courant continu (1) par l'intermédiaire de première et seconde résistances (8, 9), ces points de connexion constituant des bornes de sortie de l'oscillateur, en connectant des émetteurs desdits premier et second transistors (5, 6) à l'autre borne de ladite source d'alimentation courant continu (1) par l'intermédiaire d'une première source de courant (7) et en connectant des bases desdits premier et second transistors (5, 6) à un circuit de polarisation (10) pour appliquer une tension de polarisation; un premier port (4) d'un résonateur à ondes acoustiques de surface (2) présentant une fréquence de résonance de plusieurs centaines de MHz comportant au moins deux ports (3, 4) sur un premier substrat est connecté entre lesdites bases desdits premier et second transistors (5, 6), dans lequel les polarités de connexion d'au moins deux ports (3, 4) ou la distance acoustique

entre eux sont ou est telle(s) que les tensions au niveau de ces ports sont en phase l'une avec l'autre, un collecteur d'un troisième transistor (27) est connecté à la première borne de ladite source d'alimentation courant continu (1), un émetteur dudit troisième transistor (27) est connecté à l'autre borne de ladite source d'alimentation courant continu (1) par l'intermédiaire d'une troisième résistance (31) ou d'une seconde source de courant (35), une base dudit troisième transistor (27) est connectée audit collecteur dudit premier transistor (5), un collecteur d'un quatrième transistor (28) est connecté à la première borne de ladite source d'alimentation courant continu (1), un émetteur dudit quatrième transistor (28) est connecté à l'autre borne de ladite source d'alimentation courant continu (1) par l'intermédiaire d'une quatrième résistance (32) ou d'une troisième source de courant (36). une base dudit quatrième transistor (28) est connectée audit collecteur dudit second transistor (6) et au moins l'un des ports restants (3) dudit résonateur à ondes acoustiques de surface (2) est connecté entre un premier noeud de connexion entre ledit émetteur dudit troisième transistor (27) et ladite troisième résistance (31) ou entre ladite seconde source de courant (35) et un second noeud de connexion entre ledit émetteur dudit quatrième transistor (28) et ladite quatrième résistance (32) ou ladite troisième source de courant (36) de telle sorte qu'une tension continue ne soit appliquée ni au niveau des ports (3, 4) du résonateur (2) ni entre lesdits ports (3, 4) du résonateur (2).

2. Oscillateur selon la revendication 1, dans lequel ledit circuit d'amplificateur différentiel comprend en outre une première diode (29) connectée entre ledit premier noeud de connexion et ledit émetteur dudit troisième transistor (27); et une seconde diode (30) connectée entre ledit second noeud de connexion et ledit émetteur dudit quatrième transistor (28).

3. Oscillateur selon la revendication 1, dans lequel ledit circuit d'amplificateur différentiel comprend en outre une troisième résistance (33) connectée entre ledit premier noeud de connexion et ledit émetteur dudit troisième transistor (27) et une quatrième résistance (34) connectée entre ledit second noeud de connexion et ledit émetteur dudit quatrième transistor (28).

4. Oscillateur selon l'une quelconque des revendications 1 à 3, dans lequel tous les circuits à l'exception dudit résonateur à ondes acoustiques de surface sont intégrés sur un second substrat.

5. Oscillateur selon l'une quelconque des revendications 1 à 3, dans lequel lesdits premier, second, troisième et quatrième transistors sont constitués par des transistors à effet de champ.

FIG. 1

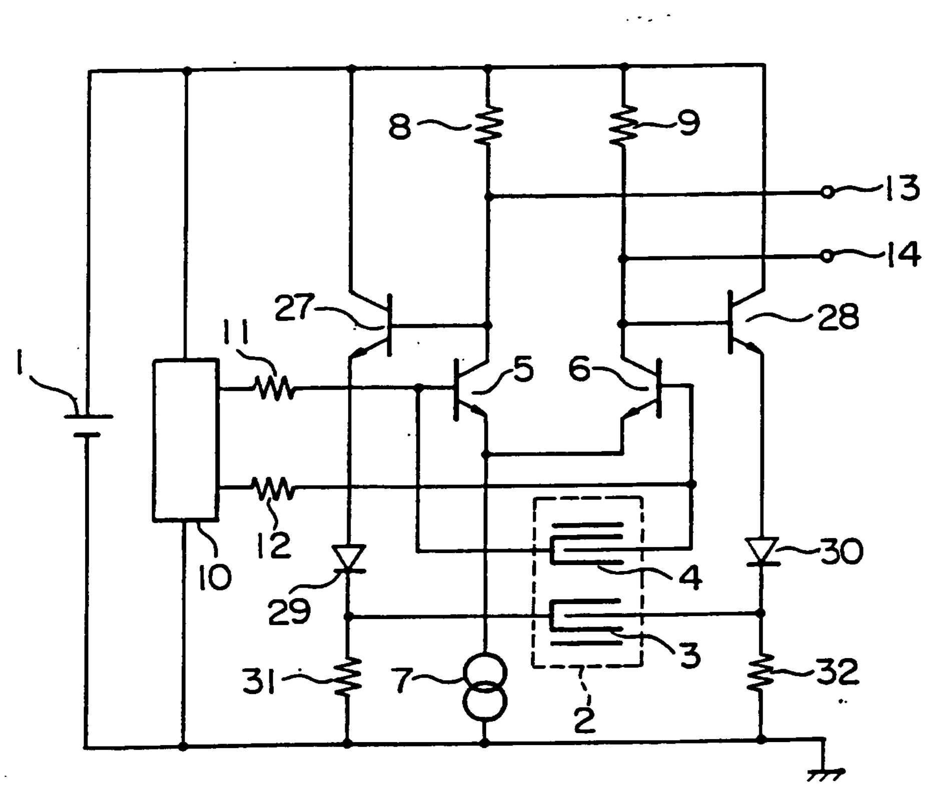

FIG. 2

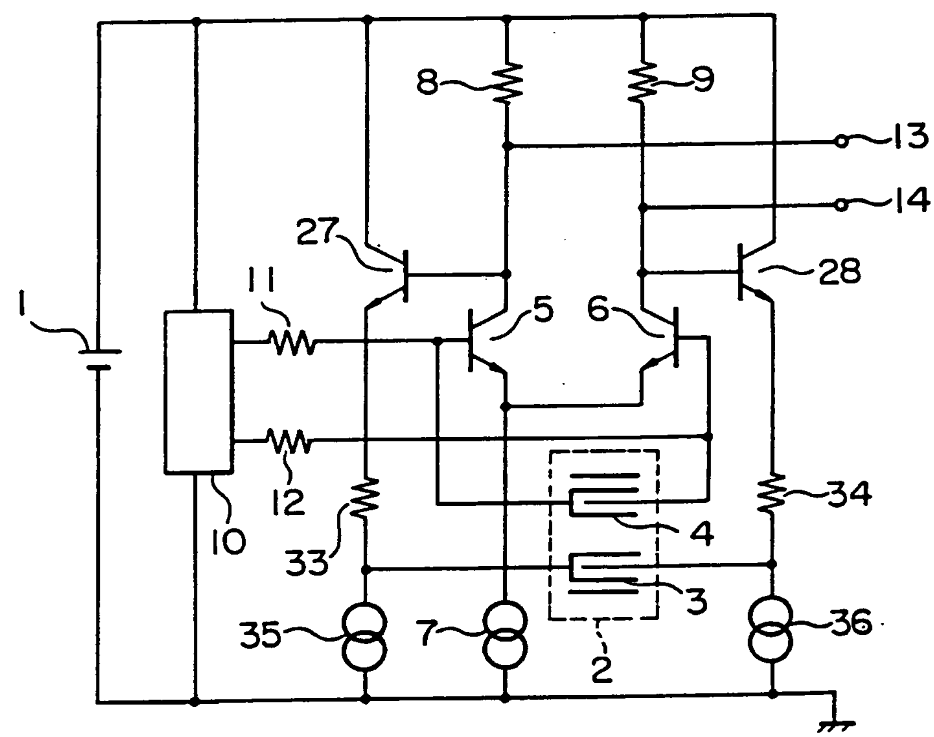

FIG. 3

PRIOR ART